

### A88-1R

Primary lithology-porphyritic basalt with phenocrysts of plagioclase and olivine in a fine-grained, quench-textured groundmass.

Secondary lithology-slightly weathered basalt

#### Phenocrysts

Plagioclase-largest ~2.9 mm, generally rounded or subhedral

Olivine-sparse, euhedral to embayed, most less than ~0.3 mm, largest ~0.8 mm. Very fresh.

Groundmass-dark brown, semi-opaque, dominated by radiating, quench-textured aggregates of plagioclase (and pyroxene?). Numerous vesicles ~0.04 to 0.25 mm.

### A88-2R

Primary texture-porphyritic basalt with phenocrysts of plagioclase, olivine and minor clinopyroxene in a hyalopilitic groundmass.

Secondary texture-slightly weathered basalt

#### Phenocrysts

Plagioclase-euhedral to skeletal, largest ~4.2 mm, very fresh, Most strong zoning confined to outer rim areas.

Olivine-euhedral to skeletal forms, largest ~4.6 mm, very fresh. Contains inclusions of: glass (pale brown, fresh), minor plagioclase and chromite (reddish brown, largest ~0.1 mm).

Clinopyroxene-minor

Groundmass-hyalopilitic, with dark, semi-opaque "glass" and skeletal plagioclase microlites. Tiny vesicles filled with yellowish, nearly isotropic secondary material (palagonite?).

### A88-3R

Primary texture-porphyritic basalt with phenocrysts of plagioclase and olivine in a gradational, glassy groundmass.

Secondary lithology-very fresh basalt

#### Phenocrysts

Plagioclase-mostly euhedral, lath-like to blocky. Rather clear and free of inclusions. Some phenocrysts contain large melt inclusions and have embayed margins. Two phenocrysts have tiny plagioclase-olivine clots clinging to their margins.

Olivine-very fresh, euhedral to skeletal, largest ~4.2 mm. Inclusions: plagioclase laths and pale brown glass.

Groundmass-gradation in form across slide:

1) glassy variolitic texture at one end. Microlites are enclosed within a brown spherulitic structure, which is within pale brown glass. Grades into

- 2) a dark, hyalopilitic texture with skeletal plagioclase microlites.

#### **A88-4R**

Primary lithology-porphyritic basalt with phenocrysts of plagioclase, olivine and minor clinopyroxene in a very fine-grained groundmass.

Secondary lithology-slightly weathered basalt

##### Phenocrysts

Plagioclase-euhedral, blocky to lath-like, largest ~4.75 mm. Most very clear and free of alteration.

Olivine-euhedral to skeletal, largest ~2.0 mm. Most fresh, but some minor partial replacement by carbonate.

Clinopyroxene-minor

Groundmass-semi-opaque and very fine-grained; comprised of skeletal plagioclase microlites, skeletal pyroxene and very fine-grained opaques or other material.

Round vesicles (up to ~0.45 mm) are mostly filled with carbonate and fine-grained, bright green material. Other irregular voids contain similar material plus palagonite(?).

#### **A88-5R**

Primary lithology-porphyritic basalt with phenocrysts of plagioclase and olivine in a fine-grained intergranular to intersertal groundmass.

Secondary lithology-slightly weathered basalt

##### Phenocrysts

Plagioclase-blocky to lath-like, complete gradation to groundmass plagioclase.

Largest ~5 mm across. Generally euhedral with irregular projections or skeletal overgrowths on grain margins. Phenocrysts are clear or contain variable amounts of crystalline inclusions, consisting of:

- 1) feathery or radiating pyroxene grains.
- 2) dark aggregates resembling groundmass(fine grained pyroxene and opaques).

Olivine-fresh, mostly anhedral forms. Largest ~1 mm wide.

Groundmass-fine-grained intergranular to intersertal, comprised of: plagioclase microlites, prismatic pyroxene aggregates, and very fine-grained opaques. Intersertal areas contain yellowish to green secondary material. Vesicles, up to ~0.5 mm, contain similar material; some contain carbonate also.

#### **A88-6R1**

Primary lithology-porphyritic basalt with phenocrysts of plagioclase and olivine in a fine-grained intergranular to intersertal groundmass.

Secondary lithology-slightly altered basalt

### Phenocrysts

Plagioclase-mostly, euhedral, blocky to lath-like, largest ~5.3 mm long. Complete gradation to groundmass. Some deeply embayed forms. Outer margins have irregular projections or skeletal overgrowths. Phenocrysts are clear or contain variable amounts of inclusions, consisting of:

- 1) dark, fine-grained aggregates of pyroxene and opaques.
- 2) in one phenocryst-euhedral olivine and glass.

Very similar to the phenocrysts of A88-5R.

Olivine-mostly fresh, euhedral to skeletal, largest ~0.7 mm. Some partial replacement by carbonate and yellowish material.

Groundmass-mostly very fine-grained intergranular to slightly intersertal, comprised of: plagioclase, parallel to slightly radiating pyroxene aggregates and opaques. Irregular former voids now mostly filled with carbonate and brown to yellowish secondary material.

## **A88-6R2**

Primary lithology-porphyrific basalt with phenocrysts of plagioclase and olivine in a fine-grained intergranular groundmass.

Secondary lithology-slightly weathered basalt.

### Phenocrysts

Plagioclase-mostly euhedral, blocky to lath-like forms, largest up to ~5 mm. Complete gradation to groundmass plagioclase. Grain margins have irregular projections or skeletal overgrowths. Some have deep angular embayments. Variable development of inclusions, similar to those in A88-5R and A88-6R1.

Olivine-very fresh, skeletal to anhedral, typically ~0.07 to 0.3 mm, largest ~1.5 mm.

Groundmass-intergranular, comprised of: skeletal plagioclase microlites, skeletal pyroxene and opaques. Scattered, irregular voids are largely filled with yellowish-brown material and carbonate.



## A89-1R

Primary lithology-vesicular, glomerophyric basalt with phenocrysts of plagioclase, clinopyroxene and olivine in a variolitic to fine-grained, quench-textured groundmass.

Secondary lithology-altered, veined and brecciated basalt.

The fine-grained groundmass is in contact with the variolitic groundmass along an irregular, slightly brecciated boundary. Fractures and slight brecciation occur throughout the rock. Similar phenocrysts occur in both types of groundmass.

### Phenocrysts

Plagioclase-mostly slender lath-like with skeletal overgrowths, ~0.2 to 2.2 mm. Phenocrysts are entirely replaced by specks of pale yellowish green (?) and albite?

Clinopyroxene-subhedral to anhedral, up to ~0.5 mm. Most is tied up in glomerocrysts with plagioclase and olivine.

Olivine-euhedral to subhedral, up to ~0.6 mm, entirely replaced by pale green serpentine? ["worm-like" structure, low bf.] and [small, irregular, brownish grains]. Most is tied up in glomerocrysts with plagioclase and clinopyroxene.

### Groundmass-two distinct types:

- 1) variolitic-spherulitic structures enclosing some, but not all phenocrysts and glomerocrysts. Structures are enclosed within brown material.
- 2) fine-grained, quench-textured-composed of minute plagioclase microlites and opaques which are interstitial to indistinct, feathery aggregates of skeletal pyroxene. Vesicles-minor, up to ~0.5 mm, filled with colorless to pale green serpentine?

Veins-largest along margin of slide, at least 0.15 mm wide, composed of carbonate and yellow-brown material. Numerous very narrow, irregular and discontinuous veinlets containing carbonate, yellow-brown material and serpentine? cut through the rock.

## A89-2R

Primary lithology-vesicular, porphyritic basalt with phenocrysts of plagioclase, clinopyroxene, olivine and Fe-oxide in a fine-grained, intersertal groundmass.

Secondary lithology-altered and veined basalt.

### Phenocrysts

Plagioclase-euhedral, blocky to narrow laths, largest >4.8 mm. Complete gradation to groundmass. Most phenocrysts variably clouded and replaced by:

- 1) unidentified fine-grained material
- 2) patchy fibrous amphibole (yellowish to green)

3) irregular, clouded network of (albite?)[colorless, 1st order gray] and

4) trace of carbonate

Pyroxene-euhedral to anhedral, fresh, largest ~2.3 mm long, partially includes some plagioclase laths.

Olivine-euhedral to skeletal, largest ~1.7 mm. Completely replaced by

1) serpentine? [green, wavy ext., "wormy" structure]

2) pale yellow to blue-green amphibole? Some brownish material may be oxidized.

Fe-oxide-up to ~0.3 mm, one encloses pyroxene and plagioclase.

Groundmass-very fine-grained intersertal, composed of plagioclase microlites, irregular pyroxene grains or aggregates with undulating extinction and opaques. Intersertal voids contain green to brownish secondary material. Round vesicles and other irregular voids contain material similar to that replacing olivine. A few "ghost" vesicles contain acicular opaques in contrast to granular opaques in the surrounding groundmass.

Veins-generally narrow (up to ~0.15 mm) and irregular. Contain yellowish to reddish brown (oxidized?) fibrous amphibole. A core of Fe-oxide is present along many veins. A small amount of carbonate is present in one vein. The veins are later than the olivine alteration and vesicle fillings.

## A89-5R

Primary lithology- vesicular, porphyritic basalt with phenocrysts of plagioclase, clinopyroxene, olivine and Fe-oxide in a fine-grained intergranular groundmass.

Secondary lithology-slightly altered and veined basalt.

### Phenocrysts

Plagioclase-generally euhedral, lath-like; mostly fresh and clear. Largest ~3 mm long. Typically forms clots with pyroxene.

Pyroxene-all very fresh. Most appears to be clinopyroxene, but one grain with parallel ext.

Olivine-generally skeletal forms, up to ~0.7 mm. Completely replaced by fine-grained mosaic of chalcedony? and other brown material.

Fe-oxide-minor, up to ~0.5 mm; some surrounded by a rim of chalcedony? A vague swath of opaques perpendicular to the orientation of the veins may be of secondary origin.

Groundmass-mostly fine-grained intergranular, composed of plagioclase microlites, skeletal pyroxene grains or clusters, granular to elongate opaques and a very small amount of intersertal material.

Vesicles are filled with spherulitic and granular chalcedony, fibrous amphibole and other fine-grained, brown material.

Veins-parallel arrangement of veins across thin section. Contain:

- 1) fine-grained mosaics of chalcedony
- 2) greenish to brownish fibrous amphibole
- 3) [fine-grained, brown]



## A89-6R

Primary lithology-vesicular and highly porphyritic basalt with phenocrysts of plagioclase, clinopyroxene and olivine in an intersertal groundmass.

Secondary lithology-altered and veined basalt.

### Phenocrysts

Plagioclase-blocky to lath-like, largest ~5.3 mm, complete gradation to groundmass plagioclase. Variably replaced by:

- 1) patchy to mesh-like networks of analcite
- 2) patchy to mesh-like networks of (albite?)[colorless, 1st order white], which is clouded by unidentified, fine-grained material. Phenocryst rims generally intact.
- 3) minor, green fibrous amphibole.

Pyroxene-anhedronal, fresh, largest ~0.9 mm. All appears to be clinopyroxene. Forms glomerocrysts with plagioclase.

Olivine-all is entirely replaced by yellowish to brownish (oxidized?) fibrous amphibole, similar in form to that in vesicles and veins, and bright green material.

Groundmass-intersertal, comprised of plagioclase microlites, granular to skeletal pyroxene, opaques and minor greenish to brownish secondary material in intersertal spaces. Most vesicles, up to ~1.5 mm, are filled with pale green fibrous amphibole; some are cored with analcite. Other vesicles and irregular voids contain spherulitic [fibrous, bright green]. Weak development of "ghost" vesicles similar to those in A89-5R.

Veins-dominated by analcite and cut across amygdules. Other discontinuous veinlets contain pale green, fibrous amphibole and in part have a core of analcite.

## A89-7R

Primary lithology-glassy basalt breccia

Secondary lithology-devitrified basalt breccia

### Fresh basalt clasts

Angular clasts ( up to >2 cm) composed of porphyritic basalt with phenocrysts of plagioclase, clinopyroxene and olivine in a dense, semi-opaque groundmass. One clast grades into variolitic texture. Plagioclase and clinopyroxene are fresh, but olivine is entirely replaced by yellowish brown material.

### Altered basalt clasts

Angular clasts up to ~8 mm replaced by analcite and two types of yellowish-brown material:

- 1) palagonite-structureless to faint, colloform-like form, very low birefringence.
- 2) fibrous amphibole?[fine-grained, radiating aggregates, 1st order red-blue bf.].

Matrix-Angular fragments of fresh and altered basalt, as above, plus pyroxene and plagioclase fragments. The finest material is largely replaced by palagonite and patchy to vein-like aggregates of:

- 1) analcite
- 2) carbonate
- 3) fibrous amphibole(?), as described above and
- 4) spherulitic structures, typically ~0.2 mm wide, composed of a core of structureless brown material surrounded by a shell of [radiating, fibrous, nearly isotropic]. The spherulites do not occur within any clasts or within areas of palagonite.

## **A89-8R**

Primary lithology-gabbro(?)

Secondary lithology-mylonitized, recrystallized and veined gabbro(?)

The thin section exhibits three concordant textural domains. A central pyroxene-rich band ~4 mm wide (Domain 1) is flanked on either side by Domains 2 and 3.

Domain 1-medium-grained, pyroxene-rich band.

Pyroxene-subhedral, up to ~3 mm. Clear to mottled due to patchy diallage texture and brownish coloration. Some fine-grained opaque inclusions. Partial replacement by aggregates of pale-yellowish to green amphibole.

Plagioclase-anhedral and interstitial to pyroxene, up to ~2.7 mm. Partially replaced by clouded, mesh-like (albite?)[colorless, 1st order gray-pale yellow], which truncates twinning. Minor replacement by greenish amphibole and traces of carbonate.

Fe-oxide-anhedral, interstitial to pyroxene and plagioclase.

Domain 2-fine- to medium-grained gabbro. Typical grain size ~0.2 to ~0.8 mm, largest 1.3 mm. Composed of plagioclase, clinopyroxene and Fe-oxide. Weak fabric defined by crude pyroxene banding.

Pyroxene-anhedral, equant to irregular. Grains are clear or have variable development of diallage texture. Clear grains typically contain minute opaque inclusions. Minor replacement by chlorite and amphibole; chlorite contains [small, irregular, brownish grains]. Plagioclase-subhedral to anhedral, equant to blocky. Mostly fresh and fairly clear, but some partial clouding and incipient replacement by analcite.

Fe-oxide-anhedral, interstitial, up to ~1 mm.

Domain 3-fine-grained, equigranular mosaic of plagioclase, clinopyroxene and Fe-oxide. Foliation defined by aligned, inequant plagioclase, faint opaque bands and "relict grains."

Plagioclase-anhedral, equant to slightly elongate, average grain size ~0.1 mm. Generally fresh and clear.

Clinopyroxene-anhedral and equant, average grain size ~0.08 mm. Variation in structure similar to clinopyroxene in domain 2. Grains are clear or have variable development of diallage texture. Minor partial replacement by chlorite.

Fe-oxide-anhedral and equant, average grain size ~0.04 mm. Some faint banding parallel to foliation, but one train of grains at high angle to foliation. Areas adjacent to bands are nearly devoid of the typical dispersed grains.

"Relict" grains-several euhedral, lath-like to equant plagioclase grains are situated within the domain. Largest is 4.5 x 0.7 mm. Except for the rim, the grains are largely replaced by chlorite, (albite?) and carbonate.

Veins-The most common variety, up to 0.5 mm wide, characterized by a margin of chlorite and a core of analcite or [colorless, 1st order pale yellow, para. ext.]. Some segments contain only analcite. Another type is very narrow and contains blue-green amphibole; partially replace intersected pyroxene grains.



## A90-4R

Primary lithology-heterolithologic breccia

Secondary lithology-altered and veined breccia

### Clasts

Angular to subrounded clasts (up to >23 mm) of a wide variety of porphyritic, basaltic lavas. Plagioclase, pyroxene and olivine were primary phenocrysts in most of the clasts.

Plagioclase-almost entirely replaced by patchy or vein-like, highly clouded (albite?) [colorless, 1st order gray-white], analcite and chlorite.

Clinopyroxene-mostly fresh

Olivine-completely replaced by chlorite and [small, irregular, brownish grains].

Vesicles-filled with chlorite.

### Matrix

Contains smaller rock fragments, plagioclase and pyroxene grains, all within a finer matrix of nearly opaque, reddish brown material. Partial replacement by structureless chlorite and foliated, very fine-grained amphibole?[green-yellowish green, 1st order blue], which contains abundant [small, irregular, brownish grains].

### Veins

Irregular, branching network which cuts across clasts and matrix. Veins up to ~0.5 mm wide. Dominated by analcite, with minor, dispersed [colorless, prismatic 1st order yellow, parallel ext.]. The veins cut across altered ferromagnesian phenocrysts, amygdules and chlorite patches in matrix. However, the veins are cut in 4 or 5 places by irregular veinlets containing

- 1) [pale greenish yellow, high bf.]
- 2) [colorless, 1st order gray-white]
- 3) analcite-minor.

## A90-5R1

Primary lithology-intergranular to intersertal diabase

Secondary lithology-slightly altered and brecciated diabase

Angular clasts of diabase in a granulated matrix.

### Diabase

Plagioclase-lath-like, mostly fresh, but some partial clouding by fine-grained material and chlorite.

Clinopyroxene-nearly all is fresh, intergranular form. Some grains have a narrow overgrowth of fibrous amphibole extending into chlorite patches.

Fe-oxide-equant to elongate.

Secondary products-minor patches of pale yellowish to green chlorite and opaques replace plagioclase and pyroxene. Some patches contain fibrous, brown to green amphibole.

### Matrix

Composed of granulated plagioclase, pyroxene and opaques within a finer matrix of dark, unidentifiable material. Partial replacement by granular carbonate.

## **A90-5R2**

Primary lithology-porphyrific basalt with phenocrysts of plagioclase, clinopyroxene and olivine in an intersertal matrix.

Secondary lithology-weathered or slightly altered basalt.

### Phenocrysts

Plagioclase-fresh and clear, blocky to lath-like, up to ~2.1 mm long. No gradation to groundmass microlites.

Clinopyroxene-anhedral, up to ~0.15 mm. Tends to form glomerocrysts with larger microlites.

Olivine-angular altered spots up to ~0.2 mm were likely olivine. Replaced by unidentified brown material.

Fe-oxide-one phenocryst

Groundmass-intersertal, composed of

- 1) plagioclase microlites--0.1 to 0.4 mm
- 2) granular to branching grains of pyroxene
- 3) equant to highly elongate opaques
- 4) pale brown secondary material-pervades all intersertal spaces and fills other irregular voids and round vesicles.

## **A90-6R**

Primary lithology-heterolithologic breccia

Secondary lithology-altered and veined breccia

Angular to subangular clasts up to ~19 mm.

### Clasts

- 1) Highly altered diabase-variable replacement of plagioclase and pyroxene by chlorite and carbonate. Some pyroxene partially replaced by amphibole.
- 2) Nonporphyritic intergranular basalt
- 3) Porphyritic basalt-intergranular to intersertal, phenocrysts of plagioclase, pyroxene and olivine. Olivine is entirely replaced.
- 4) Porphyritic "glassy" basalt-with dense, semi-opaque groundmass
- 5) Brecciated, porphyritic basalt-matrix contains semi-opaque, reddish Fe-oxide? and angular epidote.

### Matrix

Relatively minor amount, composed of mineral grains and unidentified, brown material.

### Veins

Very irregular, tend to be deflected around clast margins. Dominated by analcite, with minor carbonate and [radiating, acicular, 1st order white, parallel ext.].

## **A90-8R**

Primary lithology-gabbro

Secondary lithology-altered and brecciated gabbro

Subrounded clasts of altered, ophitic, clinopyroxene gabbro up to ~15 mm across in a granulated matrix.

### Gabbro clasts

Plagioclase-generally lath-like, minor amount remains fresh, most primary grain structure obliterated. Mostly replaced by:

- 1) fine-grained to prismatic aggregates of (prehnite??)[colorless, "high" bf., parallel ext.]
- 2) carbonate and
- 3) [fine-grained unidentified, dark material with low birefringence].

Clinopyroxene-mostly fresh, ophitic grains up to ~15 mm. Mottled due to variable development of diagenetic structure and amount of fine-grained inclusions. Some partial replacement by "coarse" chlorite.

Narrow veinlets cross some clasts and are truncated at clast margins. Contain: #1 above, chlorite and carbonate.

### Matrix

Contains rounded gabbro fragments and fragments of pyroxene, altered plagioclase, "coarse" chlorite, vein quartz and "coarse" #1. Much of the finest material is pale brown with low birefringence. Partial replacement by clear analcite.

## **A90-9R**

Primary lithology-coarse, pyroxene gabbro

Secondary lithology-altered and brecciated gabbro

Variably rounded clasts of coarse, ophitic gabbro (up to ~12 mm) within a granulated matrix. Some alteration took place prior to deformation as shown by possible truncated veins within clasts and fragmented vein quartz within the matrix.

### Gabbro

Plagioclase-anhedral to blocky tablets up to ~2 mm. Fresh and clear to totally replaced by:

- 1) fine-grained aggregates of [colorless, prismatic, 1st order pale yellow, para. ext.]
- 2) analcite and



3) chlorite

Clinopyroxene-ophitic to subophitic grains up to ~6 mm. Grains are mostly cloudy or mottled due to variable development of generally oriented inclusions (rod-like and patchy) or weak diallage texture. Tiny opaques (~0.02 mm) are commonly located along clinopyroxene-plagioclase grain boundaries. Partial replacement by chlorite, with [small, irregular brownish grains], and fibrous amphibole.

Fe-oxide-anhedral, interstitial to plagioclase.

Veins within clasts-contain analcite, dispersed [colorless, prismatic, 1st order yellow, para. ext.], trace of carbonate and void space. Some prismatic [unknown] project into the void space. There is the question of whether or not the vein(s) is truncated at the clast margins.

Matrix-consists of plagioclase, pyroxene, opaque and chlorite fragments in a pale brownish matrix which much of which is isotropic, possibly analcite. Patchy total replacement by analcite. Angular fragments of fine-grained vein quartz.

## A90-10R

Primary lithology-porphyrific, intersertal to subophitic diabase. Adhering matrix and small clasts suggests that the rock is a large clast.

Secondary lithology-slightly altered diabase.

### Phenocrysts

Plagioclase-euhedral, stout lath-like, largest ~7.5 mm long. Mostly fresh and clear, but some partial replacement along fractures by greenish, fibrous amphibole(?).

Clinopyroxene-anhedral, up to ~1.5 mm, similar in form to most groundmass pyroxene.

### Groundmass- intersertal to subophitic

Plagioclase-lath-like, ~0.3 to 1.1 mm. Mostly fresh, but some fine-scale fracturing, clouding by fine-grained material and partial replacement similar to that affecting phenocrysts.

Clinopyroxene-anhedral, intergranular to subophitic, largest ~1.4 mm. Partial replacement by minor greenish brown amphibole, dark brown "clay" and carbonate.

Fe-oxide-equant to elongate, generally ~0.06 to 0.15 mm.

Intersertal areas-patches and angular interstices contain finer plagioclase laths and opaques, acicular (?) and pale brownish secondary material.

## A90-11R

Primary lithology-porphyrific, (magnesian?) basalt with phenocrysts of olivine and sparse plagioclase in a fine-grained, quench-textured groundmass.

Secondary lithology-slightly altered and veined basalt

### Phenocrysts

Olivine-euhedral and glomerocrysts, up to ~0.6 mm. Entirely replaced by yellowish brown (?) and carbonate. Chromite (0.1 mm) is typically included within olivine or clings to grain margins. Plagioclase-(2), euhedral, longest 0.8 mm, with skeletal overgrowths.

### Groundmass

Composed of very fine-grained, radiating and plumose quench aggregates, many of which are visible due reddish brown alteration. Also contains delicate feathery and radiating quench crystals of pyroxene(?) up to 0.5 mm and randomly-oriented, reddish brown, needle-like structures up to ~1.7 mm in length. The plumose and linear structures may be quenched olivine(?). A few scattered chromite grains. Vesicles, up to ~1.4 mm are filled with carbonate, fibrous amphibole? and red-orange Fe-oxide.

### Veins

Narrow and minor, filled with yellowish to greenish to brownish (?) and reddish Fe-oxide.

## A90-12R

Primary lithology-siliceous mudstone?

Composition-structureless mudstone, diatom and radiolarian debris and scattered fine-sand-sized grains.

## A90-13R

Primary lithology-carbonate-cemented, poorly sorted, volcanic arenite

Composition-structureless, angular to subrounded, most grains in the range 0.04 to 0.6 mm, largest ~1.3 mm. Abundant carbonate cement.

Framework grains composed of:

- 1) plagioclase
- 2) palagonitized? glass-some with plagioclase microlites
- 3) pyroxene
- 4) volcanic groundmass-intergranular to intersertal
- 5) chlorite

### Veins

Narrow and irregular carbonate veinlets.

## A90-15R

Primary lithology-porphyritic/glomeroporphyritic basalt with phenocrysts of plagioclase, clinopyroxene and olivine in an intersertal groundmass.

Secondary lithology- slightly altered basalt

### Phenocrysts

Plagioclase-lath-like form, mostly fresh and clear, nearly complete gradation to groundmass, largest ~2.3 mm long. Some patchy replacement by [pale to brown, fine-gr., "highly" birefr.]

Clinopyroxene-anhedral, largest ~0.8 mm, most tied up in clots with plagioclase.

Olivine-entirely replaced by bright-green to brownish material and carbonate.

Groundmass-composed of plagioclase microlites, granular pyroxene, and equant to elongate opaques; interstices occupied by greenish secondary material. Round to irregular vesicles filled with green to blue-green secondary material [fine-grained to radiating fibrous] and carbonate. 'Ghost vesicles'-well developed, up to ~0.6 mm. Contain plagioclase (finer than in typical groundmass), highly elongate opaques and pale brown material. The entire structure is filled or can contain smaller vesicles filled secondary products described above.

## A90-16R

Primary lithology-

Composition-1) unidentified, sedimentary grains-dominant grain type. Very fine-grained, equant, irregular and embayed grains up to ~3.6 mm. Grains have a dark margin and contain minor diatom and/or radiolarian debris and spicules. One grain of similar, fragmented material ~6 mm across.

2) sandy mudstone and ?-subangular to subrounded, up to ~10 mm.

3) plagioclase, pyroxene and multigranular quartz grains

4) volcanic groundmass-intersertal, rather fresh

Carbonate-rich matrix contains abundant planktonic foraminiferal debris, including *Globorotalia* and *Globigerina*.

## A90-17R

Primary lithology-glassy basalt breccia

Secondary lithology-partially devitrified breccia

Clasts-angular, consisting of:

- 1) clear, pale brown glass with olivine? microlites, grading into
- 2) variolitic glass with olivine? microlites
- 3) highly angular, dense, black, semi-opaque clasts with olivine? microlites up to ~0.38 mm, minor vesicles.



Partial replacement of clear glass and finer matrix by palagonite, patchy areas and veinlets of chalcedony and a trace of analcite.

### **A90-18R**

Primary lithology-porphyrific, vesicular basalt with phenocrysts of olivine in a fine-grained, quench-textured groundmass.

Secondary lithology-slightly altered or weathered basalt

#### Phenocrysts

Olivine-skeletal, up to ~0.6 mm, entirely replaced by yellowish- to reddish brown secondary material.

Opagues-irregular, tend to be situated near vesicles.

#### Groundmass

Fine-grained, holocrystalline?, composed of crudely radiating aggregates of slender plagioclase microlites, intergranular to patchy (skeletal?) pyroxene, and opaques. Also contains randomly-oriented, altered, needle-like structures up to ~2 mm in length, similar to those in A90-11R. Quenched olivine?

Vesicles-up to ~0.4 mm, filled with very fine-grained, structureless brown material; a few contain cores of bright green material. Minor, weak development of "ghost" vesicle structure.

### **A90-19R**

Primary lithology-volcanic arenite

Composition-well-sorted, weak bedding. Grains are generally angular and range in size from ~0.2 to 0.4 mm. Composed mostly of plagioclase and analcite, with lesser pyroxene, amphibole, fine-grained volcanic groundmass, chlorite epidote and carbonate. The matrix is yellowish-brown and birefringent.

### **A90-20R**

Primary lithology-glassy basalt breccia

Secondary lithology-partially devitrified and veined breccia

Clasts-angular, up to ~20 mm, consisting of

- 1) clear to variolitic, pale brown glass with sparse plagioclase phenocrysts and abundant microlites.
- 2) very fine-grained, microlitic basalt with sparse plagioclase phenocrysts.

Clear, glassy fragments exhibit the greatest degree of alteration. Variably replaced by concentric, yellowish, isotropic palagonite and similar material with birefringence. Interstitial areas and veinlets contain:

- 1) analcite-most abundant
- 2) carbonate-trace
- 3) opaques-within tiny analcite veinlets, very minor.
- 4) (zeolite?)-occurs with analcite in veinlets.

## **A91-5R**

Primary lithology-vesicular, highly porphyritic basalt with phenocrysts of plagioclase, olivine and minor chromite in a variolitic to intersertal groundmass.

Secondary lithology-very fresh, slightly weathered

### Phenocrysts

Plagioclase- abundant, euhedral to rounded, blocky to equant, largest 6.3 mm wide. Strong discordance between phenocrysts and groundmass plagioclase. Some phenocrysts have irregular, indented margins. Unzoned or weakly zoned. Inclusions of material similar to groundmass.

Olivine-minor, euhedral to rounded, largest ~1 mm.

Chromite-minor, euhedral, reddish-brown, polished section contains several grains up to ~0.34 mm.

### Groundmass

Grades across slide from variolitic with fresh, pale brown glass to dense, semi-opaque intersertal texture with abundant plagioclase microlites. Pyroxene in the coarsest part is in the form of equant to feathery, radiating, quenched grains. Vesicles- largest ~0.9 mm, no secondary material. Some incipient "ghost" vesicle structure.

## **A91-13R1**

Primary lithology-vesicular, porphyritic basalt with phenocrysts of plagioclase, clinopyroxene and olivine in a mostly intergranular groundmass.

Secondary lithology-very fresh, but slightly weathered basalt

### Phenocrysts

Plagioclase-the largest (up to ~3.2 mm) are equant to blocky and generally rounded to some degree. Some margins are irregular and indented. Unzoned or weakly zoned, except near narrow rims. Some fractures stained with reddish Fe-oxide. Other plagioclase phenocrysts are more euhedral and lath-like and have stronger zoning.

Olivine-very fresh, skeletal to euhedral and anhedral, largest ~1.7 mm.

Clinopyroxene-anhedral, largest ~0.7 mm, most occurs in glomerocrysts with plagioclase and olivine.

### Groundmass

Mostly very fine-grained intergranular, composed of plagioclase microlites, pyroxene and fine opaques. Some intersertal areas contain yellowish secondary material. Vesicles-largest ~0.6 mm, just a few contain a thin lining of reddish secondary material.



## T783-1R

Primary lithology-interstitial to subophitic diabase

Secondary lithology-altered and brecciated diabase

Diabase clasts-angular to subrounded clasts up to ~8 mm in a granulated matrix.

Some variation in coarseness of the clasts.

Plagioclase-lath-like, very pale brown and highly clouded with fine-grained material. Albitized?

Clinopyroxene-anhedronal, partially replaced, together with plagioclase, by patchy chlorite and lesser fibrous amphibole.

Fe-oxide-equant, partially concentrated in interstitial areas in some clasts.

Veins associated with clasts-irregular, greenish veins within clasts or along a clast margin and appear to be truncated. Contain fine-grained fibrous amphibole and chlorite.

Matrix-two types:

1) The most voluminous is a brownish, granulated matrix which encloses most of the clasts. Contains smaller diabase fragments, pyroxene and altered plagioclase grains, patchy chlorite and fine-grained, unidentified material with low birefringence. Small vugs are lined with (?).

2) The second type is lighter in color and appears to "invade" or replace the first type. It is composed of a uniform, fine-grained mosaic of [colorless, equant, 1st order yellow, appears to be the same material that lines the vugs] and greenish (?).

Veins-minor, irregular veinlets may contain analcite.

## T783-2R1

Primary lithology-interstitial to subophitic diabase

Secondary lithology-partially altered diabase.

Plagioclase-lath-like, up to ~0.9 mm. Scattered patches of tightly intergrown plagioclase and pyroxene. Most is fresh, but pervasive partial replacement along fractures and in patches by chlorite.

Clinopyroxene-intergranular to subophitic. Most is fresh, but partial replacement by patchy and "spotty" aggregates of chlorite and yellowish to green fibrous (or flakey) amphibole.

Orthopyroxene-one grain found. Pale brown to pale green, parallel ext.

Fe-oxide-typically equant and ~0.7 mm wide. Largest up to ~0.7 mm and irregular. Tends to be confined to interstitial areas.

Interstitial areas-scattered, angular pockets containing brownish material and fine opaques.

Areas of alteration-occurs in several varieties:

1) irregular patches of chlorite and amphibole replacing plagioclase and pyroxene.

2) "chlorite spots"-circular areas ~0.1 to 0.3 mm across containing amphibole and chlorite.

3) larger patches of chlorite and amphibole (up to ~1 mm) similar to #1, but contain a small amount of quartz and brown material.



## T784-1R

Primary lithology-coarse, ophitic to subophitic gabbro

Secondary lithology-deformed and altered/recrystallized gabbro

Variably rounded or fragmented grains and clasts are enclosed in a mortar texture of gabbro constituents.

Plagioclase- equant to stout lath-like, largest ~4 mm long. Primary forms are largely obscured by alteration or fragmented. All plagioclase is highly clouded by fine-grained material; some is semi-opaque due to high inclusion density.

Clinopyroxene-equant to ophitic, largest intact grain ~ 4.2 mm wide. Weakly developed diallage texture. Commonly contains abundant fine opaques. Partially replaced by highly irregular, optically-continuous amphibole over areas several mm wide.

Amphibole-present in highly varied forms. Typically pale brown to green, rarely blue-green. Occurs as:

- 1) irregular grains highly intergrown with and replacing clinopyroxene
- 2) fragmented grains and mortar texture
- 3) dispersed blebs within brownish "chlorite" patches.

Veins-1) irregular veinlets of (?) [pale brownish, wavy inclined ext., 1st order pale yellow]

## T784-2R

Primary lithology-cumulate? gabbro. Isolated, coarse pyroxene in a matrix of loose plagioclase laths.

Secondary lithology-altered and veined gabbro

Clinopyroxene+amphibole-prismatic, equant and rounded, coarse clinopyroxene (up to 5-6 mm) is variably rimmed and replaced by coarse amphibole. Both are typically very irregular and deeply intergrown. Clinopyroxene is very cloudy due to fine-grained inclusions and poikilitically encloses some (altered) plagioclase.

Plagioclase-altered to "ghosts." Generally stout laths, dark and highly charged with unidentified fine material. Also contains abundant, fine epidote.

Matrix to plagioclase-contains:

- 1) fine, equant to stubby, prismatic pale brown to greenish brown amphibole.
- 2) fine-grained epidote
- 3) minor quartz (and chlorite?)

Alteration patches-irregular areas where all original texture is replaced by:

- 1) fine-grained mosaic quartz and spherulitic chalcedony.
- 2) aggregates of fine-grained amphibole
- 3) patchy chlorite (pale green, anomalous blue bf.) and
- 4) scattered epidote

Veins-in general merge with alteration patches, but there are some sharp bordered, discrete veinlets composed of:

- 1) mosaic quartz-some open voids in the cores of quartz areas
- 2) epidote and
- 3) chlorite

### **T784-3R**

Primary lithology-clinopyroxene(-amphibole?) gabbro

secondary lithology-partially altered gabbro

Plagioclase-lath-like to anhedral, largest ~4.5 mm. Variable clouding by fine-grained material and fine-scale fracturing. Coarser fractures filled with chlorite and blue-green amphibole. Partial replacement by coarser amphibole, epidote and chlorite.

Clinopyroxene-coarse, ophitic grains up to ~17 mm. Partial clouding by patches and streaks of fine-grained material and fine opaques. Partial replacement by amphibole, described below.

Amphibole-at least two distinct varieties:

- 1) coarse to multigranular, mottled aggregates of green-brown amphibole replacing clinopyroxene.
- 2) Coarse, subophitic (up to ~7 mm) to multigranular aggregates of pale yellowish to brownish green to blue green amphibole with highly variable structure. Generally clearer than that obviously replacing pyroxene.

Fe-oxide-anhedral and interstitial, up to ~0.95 mm across.

Alteration patches-areas where all original texture has been replaced by:

- 1) chlorite-pale yellowish to green; yellowish brown to anomalous blue birefringence.
- 2) epidote-irregular patches and veinlets
- 3) fibrous amphibole-patchy, acicular grains dispersed within chlorite: pale yellowish to blue-green.
- 4) [colorless, "micaceous" structure, 1st order blue].

Veins-two types of veining:

- 1) veinlets of epidote related to broader chlorite-fibrous amphibole-epidote alteration
- 2) narrow vein of thomsonite? similar to the vein in T784-R6. Clinopyroxene cut by the vein has been altered to amphibole. Vein also cuts chlorite alteration patches.

### **T784-04**

Primary lithology-clinopyroxene (-amphibole?) gabbro with cumulate texture.

Secondary lithology-altered, veined and brecciated gabbro

Clasts of intact, igneous texture up to >15 mm in a granulated matrix. Aligned, undeformed plagioclase and clinopyroxene in some clasts suggests a cumulate origin. Mosaic vein quartz within some clasts and as angular fragments suggests that alteration and veining took place prior to or during brecciation.



### Gabbro clasts

Plagioclase-equant to stout lath-like and anhedral forms up to 2 mm across. Most is very cloudy with fine-grained material. Partial replacement by chlorite, epidote and quartz.

Clinopyroxene-anhedral equant to subophitic grains up to ~1.7 mm with diallage texture. Pale brownish and clouded with fine-grained material. Partial replacement by amphibole.

Amphibole-pale green, highly charged with fine-grained inclusions. Occurs as a partial replacement of clinopyroxene, coarse grains up to ~3.6 mm within intact clasts, and irregular, multigranular streaks within the granulated matrix.

Matrix-composed of fragmented plagioclase and pyroxene, patchy fine-grained quartz, and patchy chlorite. Also contains angular fragments of vein quartz up to ~5.3 mm across.

### **T784-R6**

Primary lithology-coarse clinopyroxene(-amphibole?) gabbro

Secondary lithology-partially altered and veined gabbro

Plagioclase-subhedral blocky to anhedral, largest ~5.7 mm. Fresh plagioclase is clear or slightly clouded by fine-grained material and fine-scale fracturing. Otherwise, plagioclase is replaced by:  
1) mixed aggregate of colorless [prismatic to equant, 1st order red-orange, para.? ext.] and pale brown [undulose ext., "low" bf.].  
2) chlorite-complete replacement by "coarse" grains (with anomalous blue bf.) or along coarser fractures.

Clinopyroxene-ophitic to subophitic, largest ~9 mm across. Well-developed diallage texture.

Amphibole-broadly two main types:

- 1) Most abundant is anhedral and interstitial forming grains up to ~7 mm across. Brownish to greenish brown, but weakly pleochroic, probably due to strong brownish coloration and streaking (fine, oriented inclusions?). Contains numerous, tiny inclusions.
- 2) Minor in volume-fine-grained or fibrous, nearly colorless to green and blue-green. Occurs with chlorite in alteration pockets or forms irregular rims on or partially replaces the coarser brown amphibole.

Fe-oxide-anhedral and interstitial to plagioclase; some subhedral grains enclosed within chlorite patches.

Veins-sharp borders with brittle fracture features (passage through opened diallage parting, angular fragments within vein and bent diallage parting). One major vein contains (thomsonite?)[colorless, prismatic, para. ext, 1st order blue; microprobe analysis suggests thomsonite also.]]. This vein has the same structure and composition as a vein in T784-3R. Other veins contain analcite and chlorite.



## **T784-RB7**

Primary lithology-vesicular, porphyritic basalt with phenocrysts of plagioclase, olivine and clinopyroxene in an intersertal groundmass.

Secondary lithology-altered and veined basalt.

### Phenocrysts

Plagioclase-blocky to lath-like, up to ~3.2 mm, and glomerophytic clots. All plagioclase is highly clouded by fine-grained material. Replacement by patchy and vein-like albite? and minor analcite. Replacement along fractures by chlorite. Also some patchy replacement by [up to 1st order yellow].

Olivine-abundant, mostly skeletal, up to ~1.1 mm. Entirely replaced by greenish to brownish serpentine?.

Clinopyroxene-subhedral prismatic to anhedral, up to ~1 mm long.

Groundmass-intersertal, composed of plagioclase microlites, granular pyroxene, granular to elongate opaques and brownish interstitial material. Vesicles, up to ~0.8 mm, are filled with:

- 1) radiating aggregates of amphibole? [pale green]
- 2) [colorless, radiating, prismatic, 1st order yellow] and amphibole?
- 3) analcite and granular amphibole? and
- 4) fine-grained brown to bright green (?) [colloform, isotropic].

Veins-sharp bordered, with included angular basalt fragments, containing

- 1) mostly opaque Fe-oxide or Fe-oxide-rich material (reddish brown in normal light)
- 2) bright green(?) [colloform in part, isotropic]
- 3) minor quartz